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A STUDY OF THE LEAFHOPPER GENUS CIRCULIFER ZAKHVATKIN[1] (Homoptera, Cicadellidae)

DAVID A. YOUNG, JR.[2] AND NORMAN W. FRAZIER[3]

INTRODUCTION

THE BEET LEAFHOPPER *Circulifer tenellus* (Baker) is probably the most important species of Cicadellidae in North America. It is the only known vector of the curly top virus disease, which causes great losses to sugar beet, tomato, melon, spinach, bean, flax, and other crops in the western states. In the last half century huge sums of private and public money have been expended on research and control measures for curly top and the beet leafhopper. As a result, the literature on this subject is voluminous.

Circulifer tenellus is the only species of the genus known to occur in the Western Hemisphere. It was described as *Thamnotettix tenella* Baker (1896) and later placed in the genus *Eutettix* by Forbes and Hart (1900). Between 1900 and 1948 the name *Eutettix tenellus* was in common usage in literature.

Oman (1936) pointed out the similarity of the published illustration of the male genital characters of *Thamnotettix indivisus* Haupt (1927), from Palestine, to those of *E. tenellus* and placed *indivisus* Haupt in synonymy with *tenellus*. At the same time he expressed the hope that this Mediterranean record of *tenellus* would be confirmed by further extensive collecting. In a later publication Oman (1948) determined that *tenellus* should be associated with a number of Mediterranean species included in the genus *Circulifer* Zakhvatkin (1935), and further confirmed its presence in the Mediterranean area after studying a syntype (cotype) of *ignavus* Matsumura collected in Sicily. He was of the opinion that other records of forms from the Old World might also apply to *tenellus*.

This evidence presented by Oman led naturally to the speculation that

[1] Received for publication December 17, 1953.

[2] Entomological Research Branch, Agricultural Research Service, United States Department of Agriculture, Washington, D.C.

[3] Assistant Entomologist in the California Agricultural Experiment Station, Berkeley.

Circulifer tenellus is native not to North America, where it is the only species of the genus, but to the Old World, where it has close relatives. Such speculation also raised the possibility that in the Old World there might be found effective parasites or predators which were not present in the New World. This possibility was strengthened by the existence of only two records of beet leafhopper occurrence in the Old World.

As a result of the heavy losses suffered from curly top disease in 1949 and 1950 in California, the Department of Biological Control of the University of California undertook a project to search for and import into California parasites and predators to aid in the control of the beet leafhopper. As an initial phase of the project, the junior author in 1951 spent seven months in the Mediterranean area studying museum collections and making field collections to obtain as much information as possible concerning the beet leafhopper and its relatives in order to establish a basis for further search for parasites or predators.

Field collections were made in 1951 in the following countries: Algeria, April 1 to 14; Tunisia, April 15 to 21; Egypt, April 22 to May 12; Syria, May 13 to 17; Lebanon, May 18 to 23; Cyprus, May 24 to 31; Turkey, June 1 to 14; Greece, June 15 to 21; Italy, June 25 to 27; Sardinia, June 29 to July 5; Sicily, July 11 to 20; Tripolitania, July 24 to 31; and Spain, August 5 to 20.

The junior author made a preliminary report on this survey trip (Frazier, 1953), in which he included Spain in the Old World distribution of *Circulifer tenellus*. It should be specified that the records for Spain apply to *tenellus* in a broad sense, and that no specimens of the typical subspecies were found in Spanish collections. A new subspecies, described in the present study, was found in two Spanish localities.

More than 4,000 specimens of *Circulifer* were collected. These, together with several hundred specimens present in the United States National Museum, Washington, or borrowed from the British Museum (Natural History), London, and the Muséum National d'Histoire Naturelle, Paris, constitute the material for the present study.

TAXONOMY

Description. The genus *Circulifer* was described by Zakhvatkin (1935:111) with *Thamnotettix* [*Jassus*] *haematoceps* (Mulsant and Rey), 1855, designated genotype. As here interpreted, the genus includes all deltocephaline leafhoppers with a biramous aedeagal shaft, the rami of which together form a circle. Specimens range in size from 2.2 to 3.8 mm. The head varies from well produced and distinctly deltoid to almost parallel margined when viewed from above. The forewing possesses a well-defined appendix and three anteapical cells, the outer of which is often greatly reduced. There is no cross vein between the two claval veins, and rarely are these veins confluent near their midlengths. The seventh sternum of the female is emarginate medially on the posterior margin; the emargination may or may not bear a small tooth and frequently is margined with black. The male pygofer possesses a process that arises caudoventrally and extends dorsally but does not exceed the pygofer margin, either dorsally or posteriorly, in lateral aspect. The

male plates are provided with a uniseriate group of macrosetae which are marginal near the base and discal near the apices of the plates. The row of macrosetae does not attain the apex of the male plates.

As here interpreted, *Distomotettix Ribaut*, 1938 (type *Jassus fenestratus* H.–S., by original selection), which Oman (1948) placed in synonymy under *Circulifer*, constitutes a separate genus. No intergrading forms were found in which the apex of the aedeagus was intermediate between the somewhat semicircular rami of the shaft in *fenestratus* and the almost complete circle found in typical *Circulifer*. The apex of the female seventh sternum in *Distomotettix* has variations not found in typical specimens of *Circulifer* or in closely allied species, and an additional point of difference has been found in the base of the second valvula of the ovipositor. Undoubtedly the two genera are closely related.

Distribution. From what is known of the ecology of the species of *Circulifer*, all appear to inhabit regions that are relatively dry. In North America, eastern extensions of the range as far as Illinois from the West, apparently made during abnormally dry years, have been temporary so far; the species has not survived weather conditions more nearly typical for the invaded regions. The distribution pattern for the genus is remarkably similar to that recently discussed by Sailer (1952) for the pentatomid genus *Mecidea*. Sailer pointed out that the genus *Mecidea*, and certain other groups of organisms, exhibited a distribution pattern that included the Mediterranean basin, South Africa, southern South America, and southwestern North America. In addition, in the genus *Mecidea*, a form occurs in India and one in the Caribbean. Among the examples Sailer chose to illustrate this distribution phenomenon was the genus *Circulifer*, South African records of which are reported below for the first time. The range of *Circulifer* as it is known now, including western North America, the Caribbean region, southern Europe, the Near East, Transcaucasia, North Africa, South Africa, and India, is almost precisely similar to that mapped for the genus *Mecidea*, except that there are no authentic records of *Circulifer* from South America. *Circulifer* also occurs infrequently in Florida.

Character Variation. The species exhibit a remarkable dearth of differential characters, compared with those found in many other genera of leafhoppers. Intergradation between members of a given population and between populations is extremely common, and follows no geographic pattern as far as could be ascertained. Despite some biological observations made during collecting, the evidence utilized is primarily morphological, and categories have not been recognized here unless supported by discontinuity in variation of morphological characters. The results leave much to be desired. It is not certain that some of the categories will not be reduced by additional collections and discovery of intermediate forms. It is no more certain that some of the categories are not heterogeneous. The extreme range in size and form renders some of them—*opacipennis* (Leth.), for example—particularly suspect. The wide, apparently disconnected distributions of some of the forms—for example, *tenellus* ssp. *ambiguosus*—are also very unusual.

The females, particularly, are difficult to separate. This difficulty led to a somewhat protracted study of the valvulae of the ovipositor in an effort to

discover hitherto unused characters. The effort of bringing specific characters to light came to naught.

The occurrence of *tenellus* in several Mediterranean collecting sites leads to questions on the center of distribution of this species, but such questions, for the present, must be left to speculation. It should be noted that specimens from North Africa definitely exhibit more individual variation in certain respects than do specimens from western North America, and speculations on the center of origin should account for this fact.

TERMINOLOGY

In the descriptions which follow, the style of the male is considered, purely for descriptive purposes, to consist of a broad *shank* and a narrower *apical extension*. The shank bears a somewhat prominent *preapical lobe* at its extremity. The term "broad aspect" refers to a view of the style in which the greatest area of the preapical lobe is visible. In this genus, a very slight rotation of the style alters considerably the form of the sinus between the outer margin of the shank and the apical extension. For comparison with figures it has been found advisable to adjust the position of the style in such a manner that the sinus conforms as nearly as possible to the illustration, and then to make the comparison.

The terminology employed for the wing veins follows Evans' 1947 work. The apical cells of the wings are numbered from commissural to radial margin.

The "shaft" of the aedeagus refers to that portion which bears the gonoduct.

KEY TO SPECIES

1. Male plates triangular, pointed at apex, lateral margins straight or slightly sinuous, each with a row of submarginal macrosetae on or parallel to and near lateral margin almost to apex *haematoceps group* 6

—. Male plates oblong or oval, or if triangular then very irregularly so, the lateral margins then expanded anteapically; row of macrosetae usually more irregular and never parallel throughout its length to lateral margin of plate in its apical expanded portion *tenellus group* 2

2. Male style, in ventral broadest aspect with apical extension massive, scarcely tapered through most of length of extension, abruptly tapered apically, curve between shank of style and apical extension very narrow (fig. 1C); length 2.5 mm *hispaniae* n. sp., p. 30

—. Male style in broadest ventral aspect with apical extension smaller, more gradually tapered (figs. 3E, 5E-G, 4N-R, 7W-Y, 2L-Q), the curve consequently broader; length more than 2.5 mm 3

3. Male plate with length measured along mesal margin greater than width measured at midpoint of length; style with a conspicuous expansion of lateral margin of apical extension when viewed from ventral broadest aspect *dubiosus* (Mats.) 4

—. Male plate with length measured along mesal margin equal to or less than width measured at midlength; style with lateral margin of apical extension scarcely or not at all expanded *tenellus* (Baker) 5

4. Length of male usually greater than 3.0 mm, of female usually greater than 3.3 mm; male style viewed in ventral broadest aspect with apical extension more expanded along lateral margin (figs. 5E-G); male plates with lateral margins appearing more expanded laterally (fig. 5B) ssp. *infirmus* nov., p. 38

—. Length of male 3.0 mm or less, of female 3.2 mm or less, male style less expanded (figs. 4N-R); male plates with lateral margins usually not expanded (figs. 4C-G) ssp. *dubiosus* (Mats.) p. 36

5. Male plates somewhat triangular (figs. 3B, 3C); female seventh sternum usually with a minute denticle in median excision ssp. *ambiguosus* nov., p. 35

—. Male plates quadrilateral (figs. 2D-J); female seventh sternum lacking a minute denticle in median excision ssp. *tenellus* (Baker) p. 32

6. Length of male 3.4 mm or more, species robust (occurs on *Cistus*) *haematoceps* (M. and R.) p. 40

—. Length of male less than 3.4 mm, species slender, food plants varied 7

7. Style apices directed strongly laterad (figs. 8, 9) 8

—. Style apices directed caudolaterad (figs. 7W-Y) *opacipennis* (Leth.) p. 42

8. Small, length of male 2.2–2.5 mm; rami of aedeagal shaft without a mesal protuberance near apex (occurs in Spain) *nitidus* n. sp., p. 46

—. Larger, length of male 3.0 mm; rami of aedeagal shaft with mesal preapical protuberance (fig. 9D) (occurs in India) *nausharensis* (Pruthi) p. 48

Circulifer hispaniae n. sp.

(Fig. 1)

Related to *dubiosus* (Mats.), but smaller and with markedly larger style apices.

Color. Only one color form of the species is at hand. Ground color of crown pale yellow, of pronotum and forewings milky white, of scutellum dull yellow (holotype) to milky white. Crown with indistinct amber markings in form of a V, the arms extending from middle of hind margin to the ocelli (holotype), or with the V-shaped marking indicated only near the midposterior margin of the crown and with apex marked with two pairs of faintly brown transverse vittae, each pair delimiting an oval area, one on each side of the median line. Pronotum with anterior submarginal group of dark blotches (holotype) or distinct black spots; disc unmarked (holotype) or with a transverse row of four faint dark spots much less distinct than the anterior series. Scutellum with a pair of black spots each side of median line, the more anterior of the spots bordering the posterior pronotal margin, the more posterior (absent in one paratype) just behind the transverse sulcus. Forewing marked with dark to a variable degree, with at least the following dark markings present: a spot bordering anteriorly the intersection of both the claval veins and the claval suture with the commissure, the claval cross vein, a spot in outer claval cell near its midlength, cross vein m-cu, two spots in inner anteapical cell, one basal, one in apical half, a pair of similar spots in neighboring cells laterad of these, and the veins bordering the apical cells. Face pale, the clypeus margined laterally and dorsally with pale brown to black. Thoracic venter pale laterally, darker medially. Abdominal venter dark medially, pale laterally. Female pygofer pale yellow, the ovipositor slightly darker.

Form. Length of both sexes 2.5 mm. Crown deltoid, distinctly wider than pronotum, the apex rounded in dorsal aspect, median length about eight-tenths width between eyes and slightly less than median length of pronotum. Female seventh sternum usually covered basally by one of preceding abdominal sterna, and the form of the base of the median excision invisible in unmacerated specimens; allotype with excision subquadrate, without a median

tooth. Male plates trapezoidal, each with hind margin almost straight (macerated specimens), transverse, length of mesal margin approximately three-fourths width at midlength. Style in ventral broadest aspect with short shank, narrow sinus between shank and extension, and elongate massive apical extension, the latter inconspicuously narrowed in its basal portion, abruptly narrowed from mesal and outer margins just before apex; apex rounded.

Male holotype, female allotype and two female paratypes, Guardamar, Spain, 13 VIII, 1951 (N. W. Frazier). Holotype and allotype (United States National Museum catalogue no. 61756) in the United States National Museum collection, paratypes the collection of the California Insect Survey.

The host was a low scrub evergreen, 3 to 6 inches in height, growing in rocky ground.

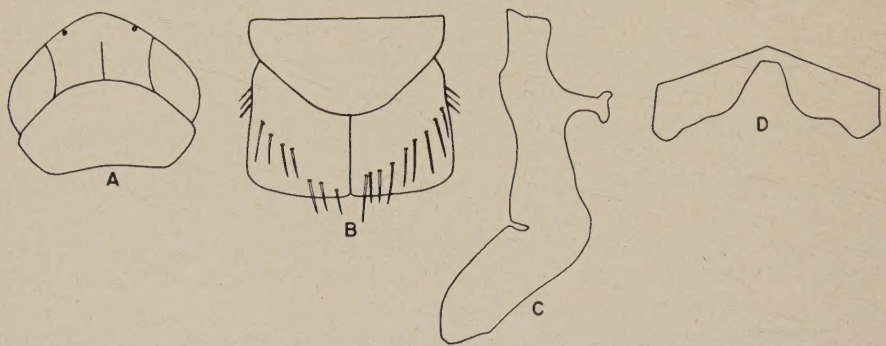


Fig. 1.—*Circulifer hispaniae* n. sp. A, Anterior dorsum, holotype; B, male valve and plates of macerated holotype; C, left style, holotype; D, seventh sternum, allotype.

Circulifer tenellus (Baker)

Thamnotettix tenella Baker, 1896, Psyche **7** (supp.):24.

Eutettix tenella; Forbes and Hart, 1900, Illinois Agr. Exp. Sta. Bul. **60**:423, 523.

Thamnotettix rubicundula Van Duzee, 1907, Buffalo Acad. Nat. Sci. Bul. **8**(5):70.

Thamnotettix ignavus Matsumura, 1908, Imperial Univ. (Tokyo) Col. Sci. Jour. **23**(6):22.

Thamnotettix indivisus Haupt., 1927, Palestine Agr. Exp. Sta. Bul. **8**:35.

Circulifer tenellus; Oman, 1948, Kansas Ent. Soc. Jour. **21**:12.

Male with apical extension of style not or scarcely expanded along lateral margin and with plates quadrilateral or modified quadrilateral (very broadly triangular, fig. 3C), the length of each plate measured along the mesal margin equal to or slightly less than width measured at midlength of mesal margin.

Circulifer tenellus ssp. *tenellus* (Baker)

(Fig. 2)

(See species heading for synonymy)

Color. Extremely variable. Most often unmarked yellow, greenish yellow or sordid green, but often marked with darker to a greater or lesser degree

(see Severin, 1930, plate 2), the markings then following the pattern described above for *C. hispaniae* n. sp. and occasionally being extensive and involving larger areas of the forewings. Specimens examined from the Caribbean region have been almost completely marked, except the cells of the forewings, with minute red dots and vermiculations to the degree that the specimens appear pink hued. Severin (1930) pointed out that in California color may be related to season and possibly to environment; he discussed the color variation occurring within a single generation.

Form. Length of male 2.8–3.5 mm, of female 3.3–3.8 mm. Crown slightly produced, rounded at apex, median length usually two thirds or less the distance between eyes, and usually about three-fifths median length of pronotum. Female seventh sternum with median excision quite variable even among individual progeny of a single female (figs. 2R–T), usually without a median denticle. Male plates quadrilateral, appearing truncate posteriorly in unmacerated specimens, but each plate with a small pointed apex that is nearly always turned dorsad and concealed in dried specimens; the smaller pointed apex distinct in macerated material (fig. 2K); shape of plates somewhat variable, but each with length at mesal margin less than width at midlength. Style in broadest ventral aspect with apical extension digitiform and typically not expanded on inner or outer margin, rarely with slight expansion on outer margin near midlength, apex rounded.

Specimens from different populations may appear quite different on comparison of head shapes. In the populations studied, the head shapes of specimens from Florida were only slightly more produced but significantly broader than the typical western North American forms; they were intermediate between the latter and the Puerto Rican forms, in which the head was both longer and broader than in the forms from western North America. The average length of specimens from North Africa exceeds that of any population examined from the Western Hemisphere, but in other characters they are within the range of individual variation of specimens from the Western Hemisphere.

Males from the population from Sabrata, Tripolitania (figs. 2P–Q) have style apices which are separable from those of typical *tenellus*, but in some specimens from Fayum, Egypt, the style apices are somewhat intermediate between typical tenellus and the Sabrata form, and in some they are within the range of individual variation found in *tenellus* in North America.

The holotype, a female from Las Cruces, New Mexico (Cockerell), is in the United States National Museum collection.

In North America the species is widely distributed in the West and as far eastward as western Kansas. It also has a restricted distribution in Florida and Puerto Rico. The known Old World distribution is listed below. Specimens have been studied from all localities listed. The numbers in parentheses indicate the size of the sample examined.

NORTH AMERICA: (**Washington**), Toppenish, Wenatchee, Pasco; (**Oregon**), Westfall, Jordan Valley, Lake View, Folley Farm, Rome, Baker City, La Grande, Union, Echo, Vale; (**Idaho**), Caldwell, Mindka, Hagerman, Jerome; (**Montana**), Stevensville; (**Nevada**), Wells; (**Utah**), Thompson, Dixie, Elsinore, Oasis, Ephraim, Green River, Marysvale, Mt. Pleasant,

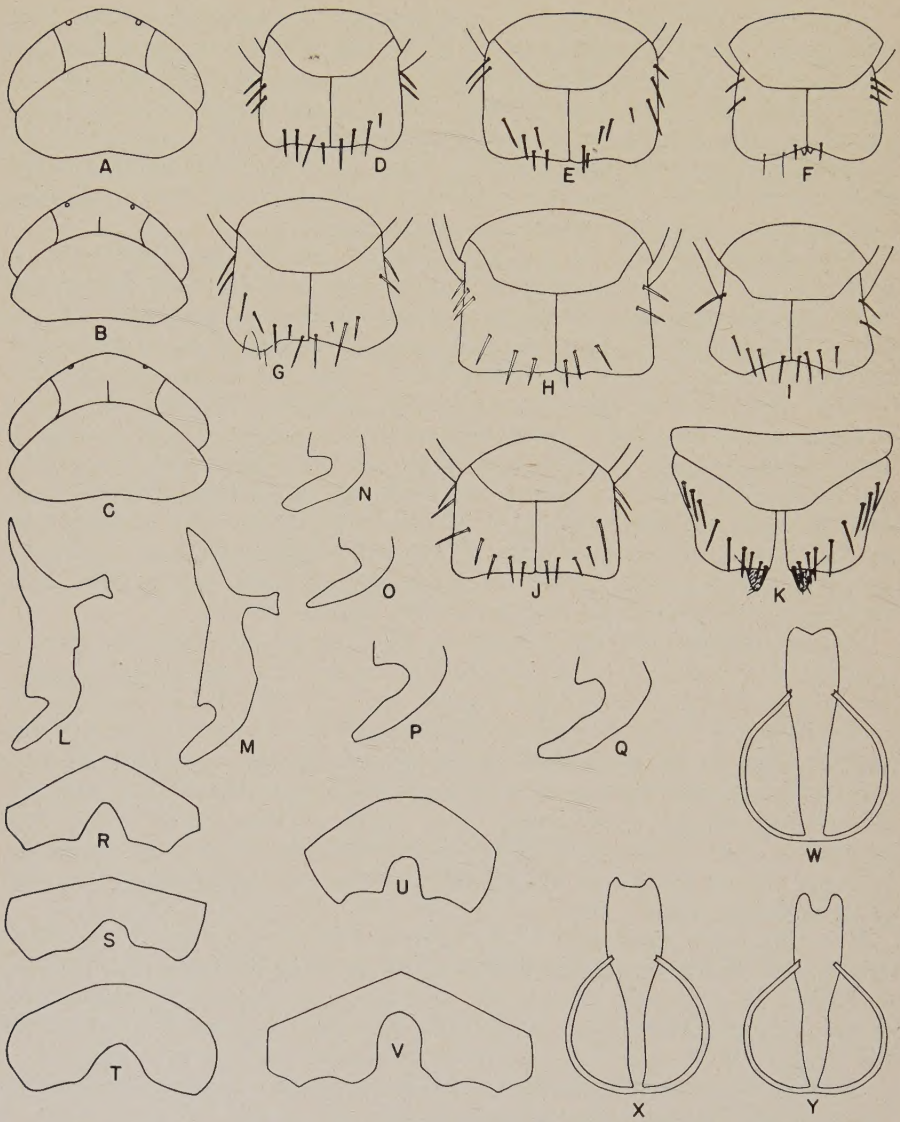


Fig. 2.—*Circulifer tenellus* (Baker). Anterior dorsum of male specimens from: A, Sabrata, Tripolitania; B, Granite Dells, Ariz.; C, Bou Saada, Algeria. Male valve and plates of specimens from: D, Fayum, Egypt; E, Glendale, Ariz.; F, Fayum, Egypt (some setae missing); G, Bou Saada, Algeria; H, Sabrata, Tripolitania; I, Fayum, Egypt; J, Granite Dells, Ariz.; K, Gila Bend, Ariz. (macerated). Left style, ventral (broad) aspect of specimens from: L, Long Valley, Ariz.; M, Cape Province, S. Africa. Style apex of specimens from: N and O, Fayum, Egypt; P and Q, Sabrata, Tripolitania; R, S, and T, seventh sternum of three females from virus colony of University of California; same structure, of specimens from: U, Fayum, Egypt; V, Sabrata, Tripolitania. Aedeagus of specimens from: W, Fayum, Egypt; X, Sabrata, Tripolitania; Y, Long Valley, Ariz.

Altos, Lynndyl, Soldier, Grove Creek, Roy, Logan, Richfield, Provo, Kanab, Lewiston, Moab, Ogden, Draper, Cisco, Moroni, Wellsville, Monroe, Lehi; (**Colorado**), Rocky Ford, Grand Junction, Palmer, Lamar, Westwater, Buena Vista, Palisade, Trinidad; (**California**), Chino, Caliente, Imperial, Doyle, Kino Bay, Visalia, Califa, Calexico, Spreckels, Cabazon, Weed, Berkeley, Wasco; (**New Mexico**), Mesilla Park, Las Cruces, Santa Fe, Organ; (**Arizona**), Kirkland Junction, Patagonia, Glendale, Yarnell Heights, Tucson, Granite Dells, Coolidge, Wickensburg, Gila Bend, Congress Junction, Lupton, Buckeye, Baboquivari Mountains, Altar Valley, Wilcox, Mt. Graham, Phoenix, Ajo Mountains, Nogales, St. Johns, Sedona, Santa Catalina Mountains, Long Valley, Kaibab, Fredonia, Bonita, Flagstaff, Williams Valley, San Francisco Mountains, Sasabe, Sabino Canyon, Chiricahua Mountains, Santa Rita Mountains, Salt River Valley, Mustang Mountain, Fort Hutchinson, Ashfork; (**Texas**), Marfax; (**Kansas**), Garden City; (**Gulf of California**), Ceralbo Island; (**Florida**), Islamoranda, Key West, Sarasota, Venice; (**Puerto Rico**), Barceloneta, Cabo Rojo; (**Mexico**), Monclova Coan, Aguascalientes, Tia Juana, Juarez.

NORTH AFRICA: (**Egypt**), Damietta (5), Siwa, Khamissa (5), Fayum (83), Suez Road (11); (**Tripolitania**), Azizia (11), Tripoli (5), Sabrata (22), Mellita (15); (**Tunisia**), Hammamet (4), Tuburbo Majus (5), Cheylus (4); (**Algeria**), Bou Saada (155); (**Anglo-Egyptian Sudan**), Khor Hanoieit (4).

SOUTH AFRICA: (**Cape Province**), Prince Albert Road (1), Calvinia (1), Mossel Bay (5), Somerset (1), Bloukraus (2); (**Southwest Africa**), Aus (7).

In addition to the distribution given above, Palestine should be added, because it is the type locality of Haupt's *Thamnotettix indivisus,* Sicily because it is the type locality of *Thamnotettix ignavus* Matsumura, and Kingston, Jamaica, because Van Duzee's *Thamnotettix rubicundula* was described from there. The introductory portion of this paper has already discussed the temporary occurrence of *tenellus* in Illinois. This was reported originally by DeLong and Kadow (1937) for the year 1936. Dr. Milton W. Sanderson (*in litt.*) of the Illinois State Natural History Survey Division stated that *tenellus* had not been taken in Illinois from 1938 to 1952, although the host plant in the locality of the previous collection was collected heavily in 1947. Mr. H. B. Petty (*in litt.*) of the same organization stated that in 1953, another very dry year, *tenellus* was collected in Madison, St. Clair, Cook, and Champaign counties.

The specimens from Fayum and Suez Road, Egypt, were collected on several species of *Zygophyllum;* those from Azizia, Tripolitania, on a species of tumbleweed (Chenopodiaceae); those from Tripoli, Tripolitania, on *Portulaca oleracea* L.; those from Sabrata and Mellita, Tripolitania, on a chenopodiaceous species growing in alkali flats near the seashore; and those from Bou Saada, Algeria, on several species of crucifers, an *Atriplex,* and other undetermined weed hosts. Food plant relationships of *C. tenellus* in North America have been the subject of a considerable amount of investigation. For an account of this (and other ecological considerations) the works of Carter (1930) and Severin (1933) may be consulted.

In the above synonymy *rubicundula* Van Duzee is listed as a synonym on the basis of Oman's examination of the Van Duzee type (Oman 1936) and as a result of examination of Oman's "compared-with-type" specimens. The name *indivisus* is synonymized on the basis of Haupt's comparison with characteristic *tenellus* (Oman 1936). No authentic specimens of *ignavus* (Mats.) have been seen, and this name is listed in synonymy because Oman so placed it after an examination of an authentic specimen. The original description of the head of *ignavus* does not conform to the common appearance of the head of *tenellus*.

Circulifer tenellus ssp. *ambiguosus*, nov.

(Fig. 3)

Color. Crown and scutellum greenish yellow. Pronotum sordidly greenish or gray on disc, the posterior margin paler and concolorous with scutellum. Forewings greenish subhyaline, the veins contrastingly lighter yellow. Face usually entirely pale, occasionally with faint dark arcs over portion of clypeus, the median portion then contrastingly paler. Venter variable, from almost completely pale yellow to yellow marked with black laterally on thorax and basally and laterally on abdomen.

Form. Length of male 2.8–2.9 mm, of female 2.9–3.7 mm. Crown deltoid, well produced, its median length from two thirds to more than three fourths its width between the eyes, much shorter than the pronotum. Female seventh sternum usually (16 of 20 specimens) with a minute tooth in median excision. Male plate subtriangular with lateral margin protuberant near midlength (figs. 3B, 3C); length measured along mesal margin equal to or slightly less than width measured at midlength of mesal margin. Style as in typical subspecies.

Holotype male, allotype female and nine paratypes, Guardamar, Spain; six paratypes, Alicante, Spain; all collected on August 13, 1951 (N. W. Frazier). Holotype (United States National Museum catalogue no. 61757), allotype and three paratypes in United States National Museum collection, other paratypes in the collection of the California Insect Survey.

Nothing is known of the host plant or plants. The type series was taken with numerous other specimens of *Circulifer* while sweeping stands of mixed weed species.

In addition to the type series, 12 specimens fitting the morphological criteria for this subspecies have been examined from Prince Albert Road, Cape Province, Africa.

This subspecies is described with misgivings. Except for the longer head, no characters have been found to separate the females from *opacipennis* (Leth.), although occasionally females with long heads are found in the Lethierry species. The modified-triangular shape of the male plates also suggests an affinity with *opacipennis*. This characteristic shape of the male plates is the most reliable criterion for separating *ambiguosus* from the typical subspecies, but one of the males collected with the types at Guardamar has plates well within the range of variation of typical *tenellus*. Possibly ecological factors are responsible for preventing complete intergradation.

Circulifer dubiosus (Matsumura)

Thamnotettix dubiosus Matsumura, 1908, Imperial Univ. (Tokyo) Col. Sci. Jour. **23**(6):18.

Circulifer dubiosus; Oman, 1948, Kansas Ent. Soc. Jour. **21**:13.

Male with apical extension of style definitely expanded along lateral margin and with plates oblong, the length of each plate measured along the mesal margin greater than width measured at midlength of mesal margin.

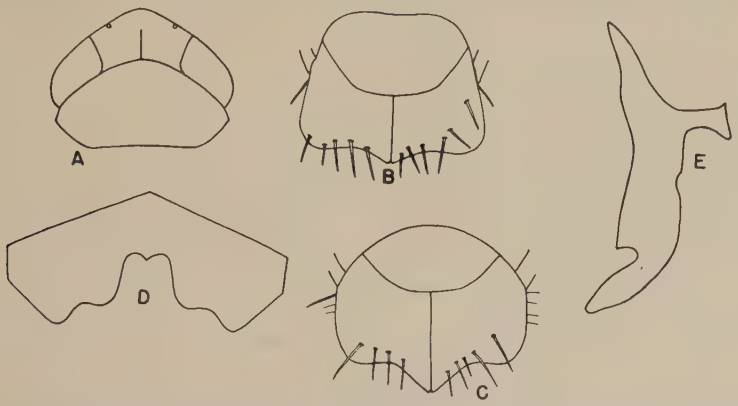


Fig. 3.—*Circulifer tenellus* ssp. *ambiguosus* nov. A, Anterior dorsum, holotype; B and C, male valve and plates of two males from same population; D, female seventh sternum; E, style, ventral (broad) aspect.

Circulifer dubiosus ssp. *dubiosus* (Matsumura)
(Fig. 4)
(See species heading for synonymy)

Color. Crown dull yellow, distinctly paler than pronotum, usually unmarked (syntype), rarely with pair of pink arcs, one on each side of midline near apex, very rarely with pair of faint pink markings on posterior portion of disc. Pronotum weakly sordid gray on disc, paler peripherally. Scutellum usually unicolorous, concolorous with crown or slightly darker, rarely marked with one or two pairs of darker markings along anterior margin. Forewing extremely variable, from unmarked yellowish hyaline with all veins contrastingly brighter yellow (female syntype) to yellowish hyaline (male syntype) or greenish hyaline with some of the veins dark (claval veins, veins bordering apical cells and m-cu cross vein, in syntype, other specimens with dark coloration approximately as in description of *C. hispaniae*, above). Face with clypellus usually entirely pale yellowish; clypeus usually with dark markings greatly variable; pale ventrally and much darker dorsally and laterally, or with a pale median vitta bordered with dark arcs on each side (syntypes of each sex), or with a triangular dark mark on each side near midlength of clypeus; lora and genae pale yellow to gray. Thoracic venter varying from completely pale, to pale medially and laterally with the intervening areas dark (syntype of each sex). Venter of abdomen variable, from completely unmarked pale yellow (except female seventh sternum) to more extensively

marked with black, the basal sterna frequently contrastingly darker than the most posterior sterna (female syntype), the latter frequently marked with black to a varying degree. Dorsum of abdomen varying from entirely

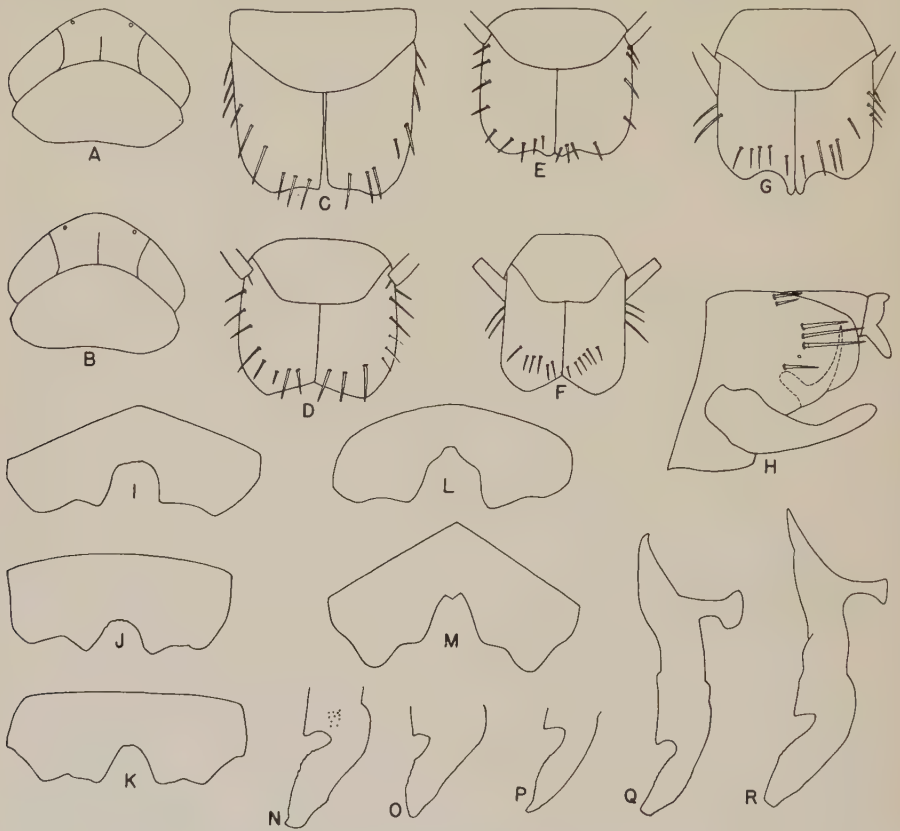


Fig. 4.—*Circulifer dubiosus* (Matsumura). Anterior dorsum of: A, male syntype from Palermo, Sicily; B, specimen from Tuz Golu, Turkey. Male valve and plates of: C, syntype (macerated); of specimens from: D, Sitges, Spain; E, Toledo, Spain; F and G, specimens from a single population, Tuz Golu, Turkey; H, male pygofer, lateral aspect, of syntype (setae of male plates omitted). Female seventh sternum of specimens from: I, Canet, Spain; J and K, Toledo, Spain (from balsam slide mounts); L, Sitges, Spain (an unusual specimen in this population); M, Tuz Golu, Turkey. Left style apex of specimens from: N and O, Barcelona, Spain (balsam slide-mount); P, Sitges, Spain. Left style of specimens from: Q, Tuz Golu, Turkey (same specimen as F, above); R, syntype.

pale to almost completely dark. Female pygofer pale yellow to greenish gray, with the ovipositor frequently concolorous but occasionally darker at sides and occasionally a contrasting amber color.

Form. Length of male 2.5–3.0 mm (usually 2.7 mm as in syntype), of female 2.8–3.2 mm (syntype female 3.1 mm). Crown produced, frequently subangulate at apex in dorsal aspect, median length from two-thirds (male syntype) to three-fourths distance between eyes. Female seventh sternum with or without a denticle in the median excision. Male plate broad, truncate

posteriorly, its length measured along mesal margin greater than width at midlength; hind margin quite variable, sinuate, transverse or oblique. Style in ventral (broadest) aspect robust, its apical extension expanded in basal half, tapered on both margins in apical half, tip truncate, very rarely acute, with minute rugae.

Specimens have been examined from the following localities: (**Turkey**), Tuz Golu (36); (**Spain**), Alicante (134), San Vicente (6), Canet (26), Escombredos (8), Toledo (123), Sitges (37), Calafell (1), Barcelona (50); (**Sardinia**), Arborea (7); (**Sicily**), Palermo (2 syntypes); (**Tunisia**), Cheylus (2).

In Tuz Golu, Turkey, the species was taken on a low-growing scrubby perennial chenopodiaceous plant growing on an alkaline lake shore. In Alicante, San Vicente, Canet, Escombredos, Sitges, and Barcelona, Spain, it was collected almost exclusively on *Lobularia maritima* Desv. (Sweet Alyssum). In Sardinia it was taken on a species of *Cistus*.

There is a great diversity in color and form. The variations are local in some cases, and individual in others. For example, in the population from Tuz Golu the degree of dark coloration appeared as an individual variation, while the form of the seventh sternum of the female was almost constant in form, with its median excision bearing a minute tooth (fig. 4M) in 24 of 26 specimens examined. The few specimens from Sardinia exhibited color variation to a similar degree; the only female captured had a suggestion of a median tooth in the excision of the seventh sternum. Most of the specimens examined from Spain were lighter in color, but with dark-marked specimens occurring as individual variations in a small number of cases. The median tooth on the seventh sternum of the females occurred only rarely. A population from Toledo, Spain, represented by many specimens, was uniformly very pale in color. Several populations studied exhibited a considerable amount of variation in the form of the male plates, but they were never short and broad as in *tenellus*.

If the above description is compared with Matsumura's original description, a discrepancy in size and color will be noted in the data presented here for the syntypes. Apparently the original series included several populations and perhaps more than one species. The identity of *dubiosus*, as used here, rests on a pair of syntypes in the United States National Museum collection.

In one of the males from Sitges, styles were found as illustrated in figure 4P. The specimen was otherwise indistinguishable from the rest of the males in the population in which the styles were typical. This form of style is believed to be an extreme individual variation.

Circulifer dubiosus ssp. *infirmus*, nov.

(Fig. 5)

Similar to typical subspecies, with the main points of difference those used in key.

Color. Dorsum variable, from uniform straw yellow to color forms with forewings marked as described above for *hispaniae* n. sp. In most of the

specimens at hand, the forewings are dark marked only at the apical portions of the apical veins. The holotype has very faint cloudy markings along the commissure between the claval veins and between the outer claval vein and the claval suture, a small faint dark mark near midlength of outer claval cell, a dark m-cu cross vein and all the apical veins dark. Crown yellow, occasionally (holotype) faintly marked with a pair of pink arcs, one on each side of midline at apex. Pronotum and scutellum usually concolorous with crown, the former occasionally darker on disc, and often (holotype) with faint darker submarginal markings near anterior margin. Abdominal dorsum varies from entirely pale to variously marked with black, the color visible

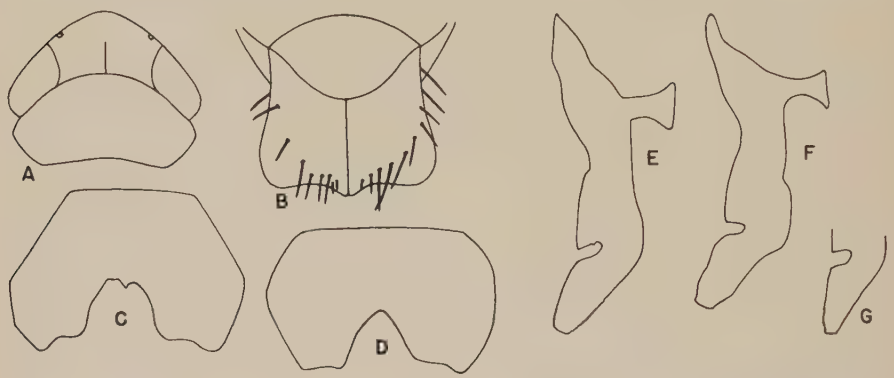


Fig. 5.—*Circulifer dubiosus* ssp. *infirmus* nov. A, Anterior dorsum, holotype; B, male valve and plates, paratype. Female seventh sternum of: C, allotype; D, paratype. Left style of E, holotype; ventral (broad) aspect, F, paratype; G, style apex of paratype; E, F, and G, are from the same population.

through the folded wings. Face pale, the clypeus embrowned laterally to a variable degree, bordering a median pale vitta of variable extent. Venter varying from almost completely pale yellow to pale with dark markings on the thoracic venter, the base of the abdomen, and on the ventral portions of the abdominal terga.

Form. Length of male 2.9–3.3 mm (holotype 3.0 mm), of female 3.3–3.7 mm. Crown deltoid, longer than in most observed populations of subspecies *dubiosus,* but intergrading with it in relationship of length of head to distance between eyes. Female seventh sternum with its posterior excision usually bearing a median tooth (present in 27 of 35 females examined). Male plates elongate oval, each with posterolateral corner expanded and broadly rounded, hind margin slightly sinuous, the mesal extremity produced posteriorly (almost never dorsally), length of mesal margin distinctly greater than width measured at midlength. Style in ventral broadest aspect with apical extension decidedly more expanded in basal portion than in typical subspecies, apex truncate.

Holotype male (United States National Museum catalogue no. 61758), allotype female, Bou Saada, Algeria, April 11, 1951 (N. W. Frazier), in the United States National Museum collection. Paratypes, same data, (48 specimens) and (50 specimens) from Azizia, Tripolitania, July 7, 1951 (N. W.

Frazier), in United States National Museum, British Museum (Natural History) London, Muséum National d'Histoire Naturelle, Paris, and the California Insect Survey collections.

This subspecies was taken on unidentified weeds in Bou Saada, Algeria, and on a chenopodiaceous species of tumbleweed in Azizia, Tripolitania.

If figures 5B and 4G are compared, much similarity will be noted in the male plates of this subspecies and those of the typical subspecies in a population from Tuz Golu. However, the Turkish males are smaller and they also differ in shape of the head and of the style.

Circulifer haematoceps (Mulsant and Rey)
(Fig. 6)

Jassus haematoceps Mulsant and Rey, 1855, Soc. Linn. de Lyon Ann. **2**:229.
Jassus haagi Kirschbaum, 1868, Nassau Ver. f. Naturk. Jahrb. 21 u. **22**:89.
Circulifer interibilis Lindberg, 1948, Finska Vetenks. Soc. Comm. Biol. **10**(7):156, new synonymy.

Color. Crown variable, unmarked brilliant red, unmarked dull red, unmarked gray to dull yellow or greenish or yellowish with irregularly arranged small maculae, or with ground color red, yellow, dull green or gray, with some or all of the following markings in red or some shade of brown: a pair of spots near posterior margin, one on each side midway between midline of crown and inner margin of eye and a pair of arcs, one on each side, each appearing subtended by a portion of the anterolateral margin. Pronotum with ground color deep red, ferrugineous, greenish or gray, the anterior margin frequently broadly paler, frequently with submarginal group of irregular black markings near anterior margin, disc often with paler midline and often with an additional pair of longitudinal paler vittae, one on each side but not touching lateral pronotal margins. Scutellum red, dull yellow, gray, or green, frequently suffused with red or marked with red maculae in a variable manner, frequently with a pair of black spots anterior to the sulcus which is nearly always black, lateral angles frequently somewhat darker than ground color. Forewings translucent with veins contrasting yellow (usually in dark forms) or red (usually in red forms), cells with some or all of following markings present and either red or black: in clavus, a blotch at inner basal angle of wing, blotches at midlength and apex of both claval cells; in corium, brachial cell partially or entirely filled, inner anteapical cell with blotches at base, midlength and apex (the last surrounding a pale anteapical areole), the outer discal cell and the middle anteapical cells each with a spot at midlength, and the second and third apical cells completely filled, the latter usually with a paler basal areole. Abdominal dorsum chiefly black. Face dull brown to dull gray, the sulci darker, clypeus variously marked, in darker forms usually only with short dark brown arcs near lateral margins, in redder forms the arcs paler brown and often extending mesad to clearly delimit a median longitudinal paler vitta; genae and dorsal portion of clypeus often with red maculae in red forms. Thoracic venter pale with longitudinal sublateral dark markings. Abdominal venter darkened to a variable degree on basal portion, paler apically. Female pygofer pale, ovipositor usually margined with black.

Form. Length of male 3.4–3.6 mm, of female 3.4–3.8 mm. Crown with median length exceeding three-fifths width between eyes, and usually less than three-fifths median length of pronotum. Female seventh sternum with shallow median excision bearing a median tooth which may be very distinct (fig. 6D) or poorly developed (fig. 6C). Male plates triangular, each with lateral margin convex in basal half, concave in apical half, a row of submarginal setae near and parallel to lateral margin of each plate, but not attaining apex. Style, in ventral aspect, with elongate apical extension directed posterolaterad, somewhat narrowed near base, broad near midlength, the apical half gradually tapered to subtruncate apex.

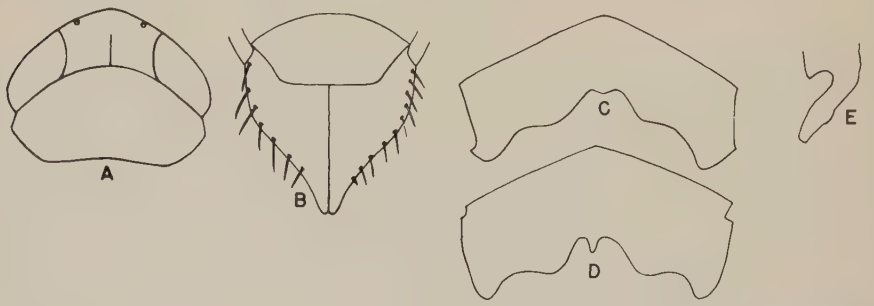


Fig. 6.—*Circulifer haematoceps* (M. and R.). A, Anterior dorsum, specimen from San Feliu, Spain; B, male valve and plates of specimen from Pollina, Sicily; C and D, seventh sternum of specimens from Siliqua, Sardinia; E, style apex of specimen from Siliqua, Sardinia, ventral (broad) aspect.

Specimens have been examined from the following localities: (**Sicily**), Pollina (9); (**Sardinia**), Siliqua (33); (**Spain**), Torroledones (48), San Feliu (39).

Cistus sp. is the only known host plant.

Structurally, this species closely resembles other species of the *haematoceps* group, but the consistently large size, the coloration, the somewhat different style apex with its slight constriction near the base of the apical extension (rare, but not unknown in other species), and the apparent restriction to *Cistus* as a food plant indicate that it is probably distinct.

Both H. L. Parker and the junior author have examined specimens, presumably from the type series, in the Rey collection at Lyon. The above interpretation of *haematoceps* appears warranted from their observations, although the males in the series are somewhat smaller (3.2 mm) than any in the series listed above. The females in the Rey collection were 3.5 mm long.

Wagner (1939, p. 182) is followed in placing *haagi* Kirschbaum in synonymy. Judging from both the original description and Wagner's remarks, the forms studied by Kirschbaum are darker than the typical form. If the dark variety is named, the Kirschbaum name is applicable, but there seems to be no reason for naming it, since both red and dark forms occur in the same population and also since specimens of intermediate color are at hand.

Circulifer interibilis which was described from Cyprus is placed in synonymy on the basis of the original description and figures. The size of the male in the original description is slightly smaller than any of the males examined in this study.

Circulifer opacipennis (Lethierry), new combination

(Fig. 7)

Cicadula opacipennis Lethierry, 1876, Soc. Ent. de Belg. Ann. **19**:lxxxiii (nec Edwards *et auctt.*).

Cicadula vittiventris Lethierry, *op. cit.*, p. lxxxiv, new synonymy.

?*Thamnotettix opaca* var. *minor* Ferrari, 1884, Ann. Mus. Civ. Stor. Nat. Genova **1**(2):514, new synonymy.

Thamnotettix unicolor Haupt (nec Melichar, 1902), 1927, Palestine Agr. Exp. Sta. Bul. **8**:34, new synonymy.

Circulifer haupti Zakhvatkin (n.n. pro *Thamnotettix unicolor* Haupt, 1927, nec Melichar, 1902), 1935, Moscow Univ. Sci. Proc. no. **4**:111, new synonymy.

Circulifer viridiflavus Lindberg, 1948, Finska Vetenks. Soc. Comm. Biol. **10**(7):158, new synonymy.

Color. Extremely variable, most often green or yellowish green unmarked dorsally. Crown most commonly unmarked green or yellow, but occasionally dull yellow or green with indistinct red maculae on disc, or with distinct red maculae on disc and apex, or with dark spots on posterior portion of disc and dark vittae near center of disc and at apex (type), or with indistinct red maculae on disc and apex, occasionally entirely dull gray, rarely completely suffused with red except a paler median vitta and a pair of pale spots behind apex, one on each side of median line. Pronotum most commonly dull slate gray on disc blending gradually with paler unmarked margins; occasionally with irregular dark markings parallel to anterior margin (type), these usually indistinct, but sometimes occurring as sharply bordered spots or blotches; occasionally with brick-red maculae; in some specimens gray or grayish green with or without dark markings parallel to anterior margin; rarely with four indistinct longitudinal darker striae. Scutellum most commonly dull yellow to green and unmarked except for dark transverse sulcus, but occasionally with one (type) or two pairs of dark spots, parallel to and near anterior margin; rarely with pair of posterior parallel short dark vittae extending caudad from extremities of transverse sulcus; occasionally entirely dull yellow or green except for slightly darker basal angles. Forewings most commonly hyaline with greenish or yellowish reflections and with veins contrasting deep yellow, but sometimes with veins red, brown, maculate with ferrugineous or red, often with some of the apical veins dark; cells in some specimens with some or all (type) of the following markings brown to some shade of black: angles subtended by confluence of claval veins with commissural margin, an area at midpoint of outer claval cell, second, third and fourth apical veins, an area near midlength of cell M, an area near middle of cell R, one at apex of cell M, and one at midlength of central anteapical cell. The undarkened portions of the cells of the type are translucent whitish,

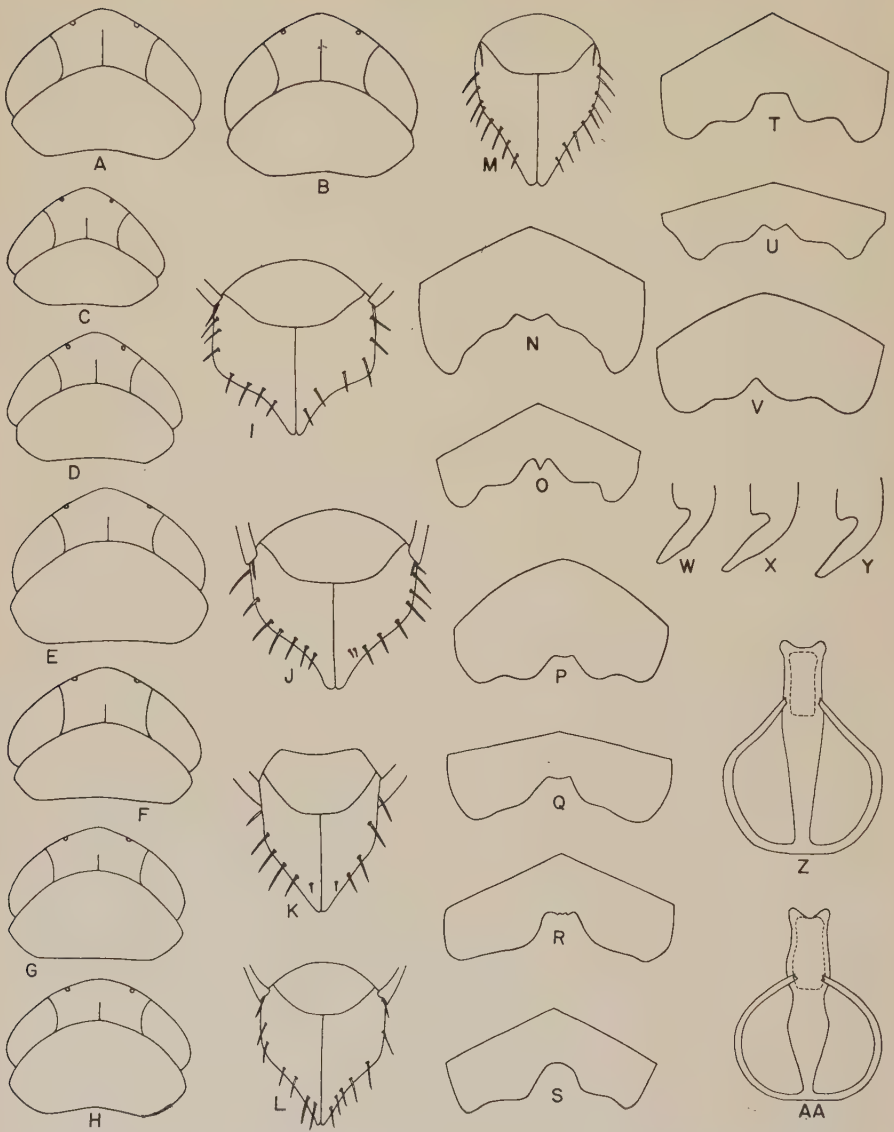


Fig. 7.—*Circulifer opacipennis* (Lethierry). Anterior dorsum of A (type) a female, and of male specimens from: B, Pera Pedi-Moniatis, Cyprus; C, Lavrion, Greece; D, El Camelen, Spain; E, Lerida, Spain; F, Font a Mare, Sardinia; G, Barouk, Lebanon; H, Lerida, Spain. Male valve and plates of specimens from: I, Tuz Golu, Turkey; J, Lerida, Spain; K, Parla, Spain; L, Tuz Golu, Turkey; M, Font a Mare, Sardinia. Seventh sternum of female specimens from: N, Astrakhan, Russia (type); O, Loeche, Spain; P, Lerida, Spain; Q, R, S, El Camelen, Spain (all from same population); T, Murcia, Spain; U, Font a Mare, Sardinia; V, Alcala, Spain. Style apex of specimens from: W, Font a Mare, Sardinia; X and Y, Lerida, Spain. Aedeagus, caudal aspect, of specimens from: Z and AA, Fraga, Spain (same population).

an unusual condition for this species. Usually the cells are transparent. Face most commonly sordid yellow with the facial sulci dark or red, and usually with at least some indication of a median clypeal pale vitta; but occasionally with sulci not contrastingly colored, and without the pale clypeal vitta; sometimes with the clypeus pale below, dark above; rarely (type) sordid yellow with very broad arcs, darker in color, comprising most of coloration of face. Thoracic venter most often yellowish or greenish, marked with a sublateral longitudinal dark vitta on each side, the dark color usually concealed by the legs in repose (type); occasionally with dark areas absent. Abdominal venter variable, from pale unmarked yellow, or yellow with irregular darker markings to almost completely dark. Abdominal dorsum usually dark with the caudal margins of the terga narrowly paler (type), but occasionally with dorsum almost completely pale yellow. Pygofer dull yellow to tan, unmarked. Ovipositor concolorous with pygofer (type), or of a deeper gray or brown.

Form. Length of male 2.3–3.3 mm, of female 2.6–4.0 mm. Crown variable from well produced and deltoid to rounded anteriorly and almost parallel margined, median length varying from half to eight tenths the distance between the eyes (in most populations from five tenths to seven tenths, seven tenths in the type), and most commonly more than half median length of pronotum, but in some populations attaining eight-tenths median length of the pronotum (six-tenths median length of pronotum in type). Female seventh sternum with median excision most often bearing a small median angular tooth, but this frequently absent in some members of most populations. Male plates triangular, their lateral margins sinuous to a varying degree. Style in ventral broadest aspect with apical extension seldom as abruptly curved as in *nitidus* n. sp., usually with concavity in outer margin before apex; apex truncate or rounded.

The localities from which specimens have been examined are listed below.

WESTERN EUROPE: (**Spain**), El Camelen (32), Alicante (17), Murcia (77), Arranquez (40), Fraga (63), Albatara (3), San Feliu (6), Lerida (83), Torroledones (50), Cartagena (143), Perales (32), Paria (52), Loeche (32), Toledo (128), Sitges (70), Barcelona (1), Alcala (134), Madrid (23), Calafell (10), Torrega (37), Guardamar (45), Escombredos (50), Bell Loch (44), Hostelrich (26), Canet (7), S. Vincente (12); (**France**), St. Cezert, Frejus; (**Italy**), Capua; (**Sicily**), Syracuse (69), Floresta (2), Palermo (28), Catania (4), Sciacca (30), Augusta (13), S. Acata, Toretta (5), Partinico (9), Avola (11), Termini (1), Aspia (1); (**Sardinia**), Capoterra (33), Marubis (3), Arborea (44), Campanasissa (2), S. Antioco (19), Cagliari (32), Musei (14), Porto Botte (5), Font a Mare (8); (**Hungary**), Budapest, Szeged, Czepel; (**Greece**), Lavrion (76), Trikkala (16), Elasson (4), Salonika (11), Brallos (10), Copais (14), Kyrnavon (33), Athens (10), Karataea (4).

RUSSIA: Astrakhan, Sartov, Ashkhabad, Caucasus, Crimea.

NEAR EAST: (**Turkey**), Polatli (89), Ankara (109), Tuz Golu (122); (**Iran**), Ahwaz (2); (**Cyprus**), Limassol (15), Larnaca (17), Morphou (18), Nicosia (17), Kyrenia (5), Brocekhane (11), Boghazi-Kyrenia (33), Kilani. Krios R. (1), Famagusta (49), Troodos (23), Pera Pedi-Moniatis (2); (**Lebanon**), Barouk (6), Damour (3), Douma (2), Sadia (2), Chikar, Beirut

(29), The Cedars (2), Aley (2); (**Syria**), Homs (6), Damascus (75), Quteife (19), Daria; (**Palestine**), Wadi Ghuzze (2), Jericho (4); (**Saudi Arabia**), Dammam.

NORTH AFRICA: (**Morroco**), Ifrane (1), Rabat (1); (**Algeria**), Bou Saada (30), El Hamet (75), Ain Sefra (3), Bougariab, Blad Touazia, Chanzy; (**Tunisia**), Tuburbo Majus (38), Zaghouan (3), Cheylus (82), Hammamet (5), Pont du Fahs (10), Tunis (2); (**Tripolitania**), Tripoli (83), Azizia (24), Zavia (3), Tigrina (37).

The specimens from El Camelen, Spain, were taken on a succulent marsh herb; from Arranquez and Fraga, Spain, on a perennial species of **Atriplex;** from San Feliu, Spain, on a species of **Cistus;** from Font a Mare, Sardinia, on **Rosemarinus officinalis** L.; from Trikkala, Greece, on **Marrubium** sp.; from Lavrion, Greece, on a species of **Salicornia;** and from Azizia, Tripolitania, on a chenopodiaceous species of tumbleweed. Other plants which were hosts in several to many localities included **Portulaca oleracea** L., **Thymus** sp., **Beta vulgaris** L., and undetermined species of **Cruciferae, Chenopodiaceae, Amaranthaceae, Polygonum, Micromeria,** and **Plantago.**

This is an extremely variable species. There is a possibility that several species are included in the specimens placed here, but it seems pointless and impractical to attempt segregation where no discontinuity in variation of morphological characters has been found, and when there is a marked lack of other biological information. It must be confessed that if a certain few of the specimens placed here had been examined without an opportunity of studying hundreds of other specimens, the number of resulting categories would have been greater.

The chief points of difference noted have been in length, size and proportion of the head, width of male plates, and color. Minor differences occur in the style apices of the males, and in the degree to which the aedeagal shaft is constricted in ventral aspect. Attempts at analysis of these differences yielded nothing to indicate they were of specific value, and intergradation occurred to the degree that for most of the criteria employed, some of the specimens had to be placed in one category or another on subjective grounds.

Some constancy was noted in some respects. In several populations the size was relatively constant, and different from that of other populations. This was particularly true of the population from Lavrion, Greece (fig. 7C), in which the length was 2.3 mm for the males and 2.6–2.8 mm for the females. In the same Lavrion population, the average ratio of the length of the head to the distance between the eyes was much greater than that found in most other populations, the head approaching the proportions of *C. nitidus,* described here, but a population from El Camelen, Spain, was found to be intermediate between the Lavrion forms and more usual forms from many other populations.

Differences in style apices, color, length, size and shape of the head, and width of male plates were not found to be distributed to form a cline.

In Spanish populations from Fraga and Arranquez, both collected on *Atriplex* sp., the portion of the crown between the eyes is longer and narrower than in specimens from most populations and the color is very pale, but intergradations occur in one of these features or another in several other populations studied.

The occasional lack of the small tooth within the excision of the female seventh sternum causes some *opacipennis* females to be indistinguishable from *tenellus* where the excision is greatly variable in form.

In a number of populations studied, there occurs a robust, pale greenish form in which the crown appears more angulate, but not longer, than in the most commonly collected form. No supporting structural differences were found to justify naming the robust form, and intergrades between it and the commoner more slender form with a more rounded crown are not rare.

A population collected on rosemary at Font a Mare, Sardinia, have styles with a preapical lobe less well developed (fig. 7W) than in other populations studied, but other characters were not found to support this difference.

The type of *opacipennis* (Lethierry), a female from Astrakhan, Russia, has been studied through the kindness of E. Séguy, of the Muséum National d'Histoire Naturelle, in Paris. Apparently the original description was based on the single female illustrated in fig. 7A; 7B. The specimen, which bore no type label, but which Séguy states is the type, and which agrees with the original description, has more dark markings on the forewings than occur in specimens from other populations examined. Its total length is 3.3 mm, including the forewings (the original description stated 2.5 mm, but there is no indication that the forewings were included in the measurement). Structurally, it falls well within the range of variation of what is considered here as a single species. Specimens of the species identified as *opacipennis* by Edwards and recently referred to the genus *Sonronius* Dorst (which Beirne has placed in synonymy under *Macrosteles* Fieber) have not been available for examination, but it seems very doubtful that they were correctly identified. The type of *opacipennis* has three distinct anteapical cells in the forewing. The ratio of the median length of the crown to the median length of the pronotum is 3.1 to 5.1, instead of 1 to 2 as the original description states.

The type of *Cicadula vittiventris* Lethierry has not been studied. The original description suggests that for many years writers have applied the name to forms conspecific with a cotype female in the museum at Paris. E. Séguy measured the cotype and found the length to be 3.65 mm (the original description stated 3 mm). He also sketched the seventh sternum of the coytpe, and it appears that there can be no doubt that the tooth in the median excision is distinct, as it is in the majority of specimens of *opacipennis* examined from a number of populations.

Thamnotettix opaca var. *minor* Ferrari is placed in synonymy with some misgivings. The original description, on the basis of a single specimen, sex not stated, from the vicinity of Tunis, is within the size range to be expected in male specimens of a population from Hammamet, Tunisia, of which only females were available. Repeated attempts to borrow the Ferrari type or to have observations made from it apparently have been ignored or have failed to reach the addressee. The form which agrees with the original description has transparent forewings with embrowned veins, but without other dark markings. The original description stated that the variety was smaller than typical *opaca*. Whether or not Ferrari's idea of the size of the true *opaca* was based on authentic material is unknown. If he accepted the length given in

Kirschbaum's original description of *opaca* (3.25 mm), then males of the Hammamet population would be of the correct size.

Circulifer viridiflavus Lindberg is placed in synonymy as the result of an examination of a specimen from the type series borrowed from the British Museum. The specimen is a representative of the paler form which was commonest in nearly all of the populations studied.

Circulifer nitidus n. sp.

(Fig. 8)

Related to *opacipennis* (Lethierry), but usually much smaller and with head more strongly produced and with style apices directed more laterad.

Color. Crown with ground color sordid gray to dull yellow, marked with red or with vermiculations to a variable degree, from few (holotype) to so

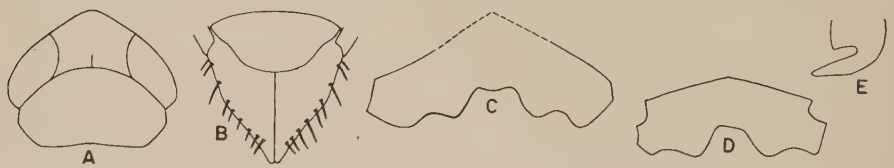


Fig. 8.—*Circulifer nitidus* n. sp. A, Anterior dorsum; B, male valve and plates; C and D, female seventh sternum; E, style apex.

many dots that dorsum of head appears almost entirely red, or with red markings confluent on anterior half and outlining a clover-leaf-shaped paler area, with the apical lobe occurring on the apex and extending slightly onto the face. Pronotum with ground color dull gray with anterior submarginal area contrastingly paler gray to yellow (holotype) and often (holotype) bearing an arcuate row of darker spots parallel to anterior margin; disc unmarked or maculate with red, the maculae varying from few and widely dispersed (holotype) to confluent. Scutellum sordid gray to dull yellow (holotype) with the transverse sulcus dark, and with or without the following markings: one (holotype) or two pairs of dark spots along anterior margin, a pair of longitudinal dark marks extending slightly caudad one from each end of the transverse sulcus, and irregular red maculae over entire surface (holotype). Forewings translucent with veins yellow, yellow speckled with red (holotype), or fuscous, those bordering third and fourth apical cells usually darker; cells variably dark-marked, the maximum coloration as described above for *haematoceps,* except that dark markings at inner angle of forewing have not been observed; cells of holotype with maximum markings in cells, except that outer discal cell is entirely unmarked. Face gray, dull yellow (holotype), or brown and variously marked with red maculae or blotches, or sanguineous, the sutures concolorous (holotype) or darker clypeus varying from fuscous with pale arcs to pale with fuscous arcs (holotype), a median paler vitta distinct or not. Thoracic venter as in *haematoceps.* Abdominal venter stramineous to dull gray, except narrow black basal portion. Entire venter frequently (holotype) maculate with red except over dark portions. Female pygofer pale, occasionally bordered with black.

Form. Length of male 2.2–2.5 mm, female 2.5–2.7 mm. Crown with median length exceeding three-fourths distance between eyes, approximately three-fourths median length of pronotum in male, more than three fourths in female. Female seventh sternum with median excision broad and shallow, with or without a median broadly convex protuberance. Male plates as in *haematoceps*. Style apex extending more laterad than in *haematoceps*.

Male holotype (United States National Museum catalogue no. 61759), female allotype, and 20 paratypes, Cartagena, Spain, 12 viii, 1951 (N. W. Frazier) in United States National Museum collection; 22 paratypes in the California Insect Survey collection, 4 paratypes in the British Museum (Natural History) London, collection, and 4 paratypes in the Muséum National d'Histoire Naturelle, Paris, collection; 10 paratypes, Murcia, Spain; other data as above, in United States National Museum collection and 10 paratypes, sama data, in the California Insect Survey collection. One specimen has also been collected in Fraga, Spain.

The host was a low scrub evergreen, 3 to 6 inches in height, growing in rocky ground. This is the same host on which *C. hispaniae* was found.

Extremely small specimens of *opacipennis* (Lethierry) fall within the size range of *C. nitidus,* but the shape of the style apices will serve to differentiate them.

Circulifer nausharensis (Pruthi)

(Fig. 9)

Cicadula nausharensis Pruthi, 1936, Indian Mus. Mem. **11**:113.

Very closely related to *opacipennis* (Leth.), and perhaps only a form of that species.

Color. Ground color of crown, pronotum, and scutellum sordid yellow, the pronotum with disc slate gray. Forewing transparent, unmarked, veins paler. Face yellow, unmarked. Thoracic venter yellow, variably marked with black. Female pygofer and ovipositor sordid yellow.

Form. Length of male 3 mm, of female 3.3 mm. Crown slightly produced, rounded at apex in dorsal aspect, median length in male more than half the width between the eyes and approximately half the length of the pronotum; slightly longer in female. Female seventh sternum with median excision broad and somewhat shallow, with a slight median tooth that is rounded apically. Male plates as in *opacipennis*. Style as in *opacipennis,* but with apex directed more abruptly laterad. Aedeagus of usual form in genus, but each ramus of shaft with mesal anteapical protuberance.

This species was described and is known only from the Punjab in North India. The above description is based on a pair of topotypic specimens, presumably paratypes. Possibly a long series of specimens would show intergradation with *opacipennis* in the two characters which set apart the males of the Indian species—the apices of the styles and the peculiar slight modification of the rami of the aedeagus. In the latter case, it is interesting to note that the illustration accompanying the original description shows the rami unmodified, suggesting the possibility that the male at hand is atypical.

The labels on the two specimens examined indicate that they were taken from the Salt Range.

SPECIES NOT STUDIED

It has not been possible to study all the species that have been associated with *Circulifer*. The following annotated list includes all such species known to the writers, except *Jassus fenestratus* Herrich-Schaeffer and its synonyms, which are now considered properly placed in *Distomotettix* Ribaut for reasons already stated. As noted below, species that appear to have been incorrectly placed in *Circulifer* are not included in the check list which follows this section.

Jassus (*Deltocephalus*) *opaca* Kirschbaum (Nassau Ver. f. Naturk. Jahrb. 21 u. **22**:125, 1868). Oman (1948) has listed this name in synonymy under *haematoceps* (M. and R.). This is not followed here, because a sketch of the female seventh sternum of the type, kindly furnished by Elli Franz, of the

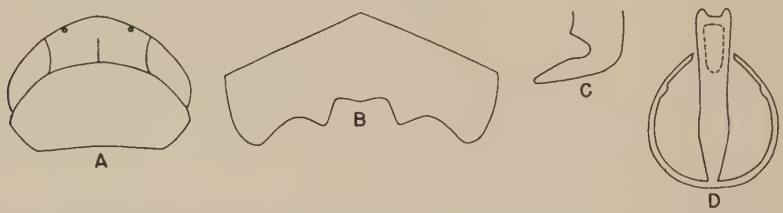


Fig. 9.—*Circulifer nausharensis* (Pruthi). A, Anterior dorsum; B, female seventh sternum; C, apex of style; D, aedeagus, caudal aspect. All from topotypic specimens, presumably paratypes.

Senckenbergische Naturforschende Gesellschaft in Wien, failed to show the small median tooth which is so commonly present in the species interpreted here as *haematoceps*. This structure, as sketched by Franz, bears a great resemblance to that frequently found in *dubiosus* (Matsumura). The original description of *opaca*, of which a portion appears to have been deleted by the printer, specifies a smaller form than *haematoceps*, and one which has discrete brownish flecks on a whitish ground color—another feature not uncommon in *dubiosus*.

Jassus (*Deltocephalus*) *rubrotinctus* Kirschbaum (*loc. cit.*). Oman (1948) placed this name in synonymy under *haematoceps* (M. and R.). Franz also supplied a sketch of the seventh sternum of the female type of this species. It does not conform to the toothed excision usually found in *haematoceps*. Franz states that the length of the type is 3.3 mm (the original description stated 2.75 mm). The red markings mentioned in the original description could apply to *haematoceps* or possibly to *tenellus*. The rounded excision sketched by Franz could apply to a specimen belonging to the *tenellus* group.

Thamnotettix haematoceps var. *futilis* Horváth (Mus. Nat. Hungarici Ann. **7**: 296, 1909) cannot be placed from the original description.

Thamnotettix inscriptus Haupt (Palestine Agr. Exp. Sta. Bul. **8**: 33, 1927). Oman (1948) and Lindberg (1948) have treated this species in *Circulifer*. The original illustration of the male plates, showing a uniseriate group of marginal macrosetae which attain the apex, represents a condition not found in the genus. Lindberg's illustration (*op. cit.*) of the male geni-

talia strengthen such a conclusion. The size of the species, as given in the original description, and the illustration of the anterior dorsum, are not characteristic of *Circulifer*.

Thamnotettix opaca varr. *diluta* and *picta* Ferrari (Ann. Mus. Civ. Stor. Nat. Genova **18**: 125, 1883). These forms were described as color varieties. They cannot be placed on the basis of the original descriptions. No reply was received to letters written to Genoa for information about types. The original description of var. *picta* agrees almost perfectly with the type of *opacipennis* (Lethierry).

Thamnotettix rubrivenosa Scott (Ent. Monthly Mag. **13**: 83, 1876). Henri Ribaut, in a conversation with the junior author, suggested that this species should be referred to *Circulifer*, a reasonable suggestion, judging from the original description. Dr. China was unable to find type material in the Scott collection in the British Museum (Natural History) London. In size and general color pattern, as originally described, the species is related to *haematoceps* (M. and R.), if not identical. A single female specimen from the de Bergevin collection, loaned by Séguy, and determined as the Scott species (determiner unknown) conformed well to the original description, except in size, being somewhat larger than Scott specified. The head was much more produced than is usual in *haematoceps*. The specimen was from Chanzy, Algeria.

Thamnotettix salus Matsumura (Imperial Univ. (Tokyo) Col. Sci. Jour. **23** (6): 21, 1908). This species cannot be placed with certainty from the original description. On the basis of comparative size between (*ignavus* Matsumura) = *tenellus* (Baker) and *salus*, it would appear that the latter probably should be referred to *dubiosus* (Matsumura), populations of which have been found marked in the manner specified in the original description.

Circulifer chinai Zakhvatkin (Roy. Ent. Soc. London Trans. **96** (9): 160, 1946) and its subspecies *caspius* (*loc. cit.*), *arabicus*, and *jenjouriste* (*op. cit.*, page 161) were described in such a manner that the names are useless to taxonomists. The three species were described each from a single female, the illustrated seventh sterna of which have been duplicated by the progeny reared from a single female of *C. tenellus* taken from the virus-vector colony maintained at the University of California. No further statement can be made concerning the affinities of the Zakhvatkin forms than to say that they appear to belong to the *tenellus* group.

Circulifer macchiae Lindberg (Soc. Sci. Fenn. Comm. Biol. **10** (7): 160, 1948). The illustrations accompanying the original description of this species indicate that it is not properly placed in *Circulifer*.

Cicadula unicolor Melichar (Wien. Ent. Ztg. **21**: 78, 1902) cannot be placed from the original description and the location of the type is unknown. One specimen, determined as *unicolor* by Zakhvatkin, loaned by the Paris Museum, does not belong in *Circulifer*.

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CHECK LIST OF SPECIFIC NAMES

(For the Young and Frazier names below, the page numbers refer to the present publication.)

ambiguosus Young and Frazier, p. 34 = ssp. of tenellus

dubiosus (Matsumura), 1908, Imperial Univ. (Tokyo) Col. Sci. Jour. **23** (6):18. (*Thamnotettix*)

ssp. *infirmus* Young and Frazier, p. 37

haagii (Kirschbaum) = haematoceps

haematoceps (Mulsant and Rey), 1855, Soc. Linn. de Lyon Ann. **2**:229. (*Jassus*)

haagii (Kirschbaum), 1868, Nassau Ver. f. Naturk. Jahrb. 21 u. **22**:89. (*Jassus*)

interibilis Lindberg, 1948, Finska Vetenks. Soc. Comm. Biol. 10 (7):156. (*Circulifer*)

haupti Zakhvatkin = opacipennis

hispaniae Young and Frazier, p. 29

ignavus (Matsumura) = tenellus

indivisus (Haupt) = tenellus

infirmus Young and Frazier, p. 37 = ssp. of tenellus

interibilis Lindberg = haematoceps

minor (Ferrari) = opacipennis

nausharensis (Pruthi), 1936, Indian Mus. Mem. 11:113. (*Cicadula*)

nitidus Young and Frazier, p. 46

opacipennis (Lethierry), 1876, Soc. Ent. de Belg. Ann. **19**:lxxxiii. (*Cicadula*)

vittiventris (Lethierry). *op. cit.*, p. lxxxiv. (*Cicadula*)

? *minor* (Ferrari), 1884, Ann. Mus. Civ. Stor. Nat. Genova **1**(2):514. (*Thamnotettix*)

unicolor (Haupt), 1927, Palestine Agr. Exp. Sta. Bul. **8**:34. (*Thamnotettix*)

haupti Zakhvatkin, 1935, Moscow Univ. Sci. Proc. no. **4**:111. (*Circulifer*)

viridiflavus Lindberg, 1948, Finska Vetenks. Soc. Comm. Biol. **10**(7):158. (*Circulifer*)

rubicundula (Van Duzee) = tenellus

tenellus (Baker), 1896, Psyche 7 (suppl.): 24. (*Thamnotettix*)

rubicundula (Van Duzee), 1907, Buffalo Acad. Nat. Sci. Bul. 8 (5):70. (*Thamnotettix*)

ignavus (Matsumura), 1908, Imperial Univ. (Tokyo) Col. Sci. Jour. 23 (6):22. (*Thamnotettix*)

indivisus (Haupt), 1927, Palestine Agr. Exp. Sta. Bul. 8:35. (*Thamnotettix*)

ssp. *ambiguosus* Young and Frazier, p. 34

unicolor (Haupt) = opacipennis

viridiflavus Lindberg = opacipennis

vittiventris (Lethierry) = opacipennis

arabicus Zakhvatkin, 1946, Roy. Ent. Soc. London Trans. 96 (9):161. (*Circulifer*)
caspius Zakhvatkin, 1946, Roy. Ent. Soc. London Trans. 96 (9):160 (ssp. of *Circulifer chinai*)
chinai Zakhvatkin, 1946, Roy. Ent. Soc. London Trans. 96 (9):160. (*Circulifer*)
dilutus (Ferrari), 1883, Ann. Mus. Civ. Stor. Nat. Genova 18:125. (var. of *Thamnotettix opaca*)
futilis (Horvath), 1909, Mus. Nat. Hungarici Ann. 7:296. (var. of *Thamnotettix haematoceps*)
jenjouriste Zakhvatkin, 1946, Roy. Ent. Soc. London Trans. 96 (9):161 (*Circulifer*)
opacus (Kirschbaum) 1868, Nassau Ver. f. Naturk. Jahrb. 21 u. 22:125. (*Jassus*)
pictus (Ferrari), 1883, Ann. Mus. Civ. Stor. Nat. Genova 18:125. (var. of *Thamnotettix opaca*)
rubrivenosus (Scott), 1876, Ent. Monthly Mag. 13:83. (*Thamnotettix*)
rubrotinctus (Kirschbaum), 1868, Nassau Ver. f. Naturk. Jahrb. 21 u. 22:125. (*Jassus*)
salus (Matsumura) 1908, Imperial Univ. (Tokyo) Col. Sci. Jour. 23 (6):21. (*Thamnotettix*)
unicolor (Melichar), 1902, Wien. Ent. Ztg. 21:78. (*Cicadula*)

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